SPECIAL MEETING.

First Session, 26th May, 1843, 10 *o'clock, A. M.*

Dr. Chapman, Vice-President, in the Chair.

The meeting was opened by the chairman with congratulations to the members on the occasion of their assembling, and expressions of welcome to the strangers who honoured it by their presence.

Dr. Bache, from the sub-committee, consisting of himself, Dr. Dunglison, and Dr. Ludlow, submitted the programme of the meeting, so far as it had been matured, and indicated the manner in which the various communications which had been received would be presented to the notice of the Society.

Letters relating to the celebration were read from—

The Northern Academy of Arts and Sciences, Hanover, N. H.,—the Rhode Island Historical Society,—the Connecticut Historical Society,—the Georgia Historical Society,—the Dean of the Faculty of Jefferson Medical College,—the Dean of the Faculty of the Pennsylvania College of Medicine,—the Hon. John Quincy Adams,—the Hon. Albert Gallatin,—the Hon. Daniel Webster,—the Rev. Dr. Samuel Miller, of Princeton, N. J.,—the Rev. Dr. Samuel F. Jarvis, of New York,—B. Silliman, Jr., Esq., of New Haven,—A. Litton, Esq., of Nashville, Tennessee,—Samuel H. Smith, Esq., of Washington, D. C.,—Professors D. H. Mahan, Hitchcock, Bartlett, and Baily, of the United States Military Academy, West Point,—Professors Peirce and Lovering, of Harvard University,—Chancellor Frelinghuysen, of the University of New York,—Professors W. B. Rogers, R. E. Rogers, and Courtenay, of the University of Virginia,—President Wayland, of Brown University,—John Pickering, Esq., of Boston,—Horatio Hale, Esq., Boston,—W. J. Andrews, Esq., Secretary of the Boston Athenæum,—Professor Olmstead, of Yale College,—Dr. T. Romeyn Beck, Albany, N. Y.,—Hon. James Madison Porter, Secretary of War,—Professor Loomis, of Western Reserve College,—Dr. Charles Caldwell, of the Louisville Medical Institute,—John L. Stephens, Esq., of New York,—Dr. William Darlington, of Chester County, Penn.,—Col. J. J. Abert, of the United States Topographical Engineers,—Dr. Mower, United States Army,—Lieut. Gilliss, United States Navy,—Dr. J. F. Ducatel, of the University of Maryland,—Professors Anderson and Renwick, of Columbia College, New York,—Professor Draper, of the University of New York,—W. C. Redfield, Esq., of New York,—Dr. Warren, of Boston,—James Espy, Esq.,—Dr. John Locke, of Cincinnati,—Professor Strong, of Rutgers College,—George Bancroft, Esq., of Boston,—and the Rev. Professor Potter, of Union College.

A letter was received and read from the General Secretaries of the British Association for the Advancement of Science, dated 31st March, 1843, inviting the Society to participate in the next meeting of the Association, to be held at Cork on the 17th of August next.

A note was presented from the Principal of the Pennsylvania Institution for the Instruction of the Blind, inviting the Society and its guests to visit the Institution. The invitation was accepted, and half past four o'clock in the afternoon was fixed upon for the visit.

A letter was read from Professor Rümker, of Hamburg, containing observations on the comet of 1843.

Professor Henry, of Princeton, presented a communication "On Phosphorogenic Emanation," and illustrated, by numerous diagrams, the experiments which he had made on the subject.

It has long been known, that when the diamond is exposed to the direct light of the sun, and then removed to a dark place, it shines with a pale bluish light, which has received the name of phosphorescence. The effect is not peculiar to the diamond, but is common to a long list of substances, among which the sulphuret of lime (Homburgh's phosphorus) is the most prominent. It is also an old fact, mentioned by Canton, that the phosphorescence is excited by exposing the substance to the light of the electrical discharge.

About three years ago, M. Becquerel, of the French Institute, repeated the experiment of Canton, and discovered the remarkable fact, that the phosphorescence is excited in a very feeble degree, or not at all, when a plate of glass or mica is interposed between the spark and the sulphuret of lime, although the effect is not apparently diminished when a plate of rock crystal or one of sulphate of lime is similarly interposed. Or, in other words, he found that substances equally transparent do not equally well transmit the exciting cause of the phosphorescence. Hence the old explanation of the glowing of the diamond, namely, that it is owing to the light which has been absorbed and is again given off in the dark, could no longer be admitted; and Becquerel inferred from his experiments, that the exciting cause of the phosphorescence was due to an impression made on the lime by a radiation from the electrical spark, differing essentially from light, and to which he gave the name of the phosphorogenic emanation.

Biot afterwards made a series of experiments on the "permeability" of different substances, in reference to this emanation as it exists in the beams of the sun; and still later, Matteucci, the celebrated Italian experimental philosopher, has investigated and extended the same subject. The younger Becquerel also has published a memoir on the constitution of the solar spectrum, including its phosphorogenic properties. From the notices of the labours of these *savans* on this subject, as they were adverted to by Professor Henry, it appears that all their experiments, with the exception of those before mentioned as made by M. Becquerel, were confined to the solar irradiation, and consequently they do not lessen the importance of a careful examination of the properties of the same emanation, as derived from a different source, and having a different intensity.

The investigations detailed in Professor H.'s communication relate almost exclusively to the emanation as derived from the electrical spark. The apparatus employed in the experiments was a Leyden jar, of the capacity of about half a gallon; and this was charged each time, so as to give a spark between the rounded ends of two thick wires of about an inch in length. The sulphuret of lime was exposed to the light of the spark at different distances, in shallow leaden pans. The first experiments relate to an examination of a considerable number of substances, in regard to their permeability by the emanation. The results of these, which were given at the close of the communication, will serve to corroborate the inference of M. Becquerel, that the exciting cause of the luminous appearance of the lime is not identical with light.

The next experiments are in reference to the propagation of this emanation. Two slits, of about the one-twelfth of an inch wide and an inch long, were made in two screens of sheet brass, and these slits were placed in the same plane with the path of the spark. After the discharge, the sulphuret of lime under the opening was observed to be marked with a narrow line of light well defined at its edges, and shaded off at its ends into a penumbra; the appearance being precisely in accordance with the laws of a radiation in straight lines from a narrow line of emanation.

Experiments were next made to determine whether the radiation of the emanation takes place with the same intensity from every point of the length of the spark, or whether it is confined to the two extremities, or the poles of the discharging wires. For this purpose, the slits were turned at right angles to their former position, so that the emanation could only reach the lime from a single point of the spark. The experiments with this arrangement showed that the radiation is from each point of the line of the spark, but that it is much more intense from the two extremities. This curious result was verified by another arrangement, which allowed the impressions from different points of the spark to be at once compared with each other. Three slits were cut in a thick plate of mica, and this was placed immediately above the lime, so that one of the slits was directly under the end of each wire, and the other midway between the other two. When the discharge was passed over the plate, the lime under the middle slit exhibited a feeble phosphorescence for two or three seconds, and then became dark, while that under the slits at the end of the spark continued to glow for more than a minute. This effect did not appear to be due to the diffusion of the spark at the middle of its course, since the discharge was from a Leyden jar, and the spark, as is usual, in this case appeared as a single line of light, of the same intensity and width throughout its whole length.

The phosphorescence was excited at a much greater distance than was at first thought possible. In a perfectly dark room, the light was observed, for a few moments, when the pan containing the lime was removed to the distance of ten feet from the point of discharge. The intensity of the light, and the time of continuance, however, diminish very rapidly with an increase of distance.

To determine whether the emanation obeys the laws of the reflection of light, a piece of common looking-glass was so arranged with the path of the spark, the slits in the screens, and the pan of lime, that the angle of reflection could be compared with the angle of incidence: but with this arrangement no impression on the lime could be obtained; the want of permeability in the glass apparently preventing any reflection from the silvered side of the mirror. A plate of polished black glass was next used, so as to get the reflection from the anterior surface: the result, however, was of the same negative character as before. It would therefore appear, that glass neither reflects nor transmits the phosphorogenic emanation, except in a very small degree. When a metallic mirror was employed, a well defined line of light was impressed on the lime from the reflected emanation, and from the position of this it was found that the two angles were equal.

The refraction and dispersion of the emanation were readily obtained, by employing for the purpose a prism of rock salt, instead of one of glass. The dispersion was shown by the conversion of the narrow line of light, by means of the prism, into a broad band.

The next question was in reference to the polarization of the phosphorogenic emanation; and in obtaining a satisfactory answer to this, several difficulties were encountered. Attempts were first made to polarize the beam by passing it through tourmaline: but it was found that this substance is less permeable to the emanation than even glass or mica. Nichols' polarizing prisms were next employed, but no impression could be made on the lime through two of them; and since the emanation is not reflected by glass, and the polarization from polished metal is very feeble, these substances could not be employed in the process. At length an indirect method was adopted, which gave positive results. This was founded on an experiment of Melloni, in his interesting researches on radiant heat. A pile of exceedingly thin plates of mica, prepared according to the method of Professor Forbes of Edinburgh, was placed between the spark and the pan containing the lime, with its plane at right angles to the line joining the middle of the two. In this position of the pile, no impression was made on the lime by the electrical discharge; but when the plane of the pile was inclined to the line just mentioned, so as to form with it the polarizing angle, a luminous spot was excited.

By this change in the position of the pile, the thickness of the path to be traversed by the phosphorogenic beam was considerably lengthened; and yet the permeability was much increased. This remarkable result could only be the effect of the successive polarization of the several parts of the beam, as they passed the several films of mica, and were thus prepared for a more ready transmission by the succeeding films.

After the emanation was found to be polarizable, it was important to determine if the intensity of the action on the lime would be different, in case the beam were transmitted through crystals in different directions, in reference to their optical axis; but no difference could be observed, when the beam was passed through crystals of carbonate of lime and quartz, parallel and perpendicular to the axis.

From the foregoing results it is evident, that the exciting cause of the phosphorescence of the sulphuret of lime, is an emanation possessing the mechanical properties of light, and yet so different in other respects as to prove the want of identity. That the same emanation also differs from heat is manifest from the fact, that the lime becomes as luminous under a plate of alum as under a plate of rock salt, although these substances are almost entirely different in their property of transmitting heat.

Some experiments were also made to compare the phosphorogenic emanation with the chemical radiation. For this purpose, a sensitive Daguerreotype plate, and a pan of sulphuret of lime, were exposed together to the light of the sky for five seconds. The plate by this exposure was marked with a photographic impression, but little or no effect was produced on the lime. Another sensitive plate and the same pan of lime were similarly exposed to the light of an electrical discharge: the lime was now observed to glow, while no impression was produced on the plate. When, however, the plate was exposed very near to a succession of sparks, continued for ten minutes, with a plate of mica interposed, an impression was made.

The sulphuret of lime was also exposed, for several minutes, to the direct light of the full moon, without any phosphorescent effect. A sensitive plate, similarly exposed, according to the statement of Dr. Draper, receives a photographic impression. These experiments, although not sufficiently extensive, appear to indicate that the phosphorogenic emanation is distinct from the chemical, and that it exists in a much greater quantity in the electrical spark, than either the luminous or the chemical emanation.

Professor H. remarked, that in considering these emanations as distinct, he had reference only to the classification of the phenomena; for if they be viewed in accordance with the undulatory hypothesis, they may all be considered as the results of waves, differing in length and amplitude, and possibly also slightly differing in the direction of vibration.

The phosphorescence of the lime may also be excited by exposure to the light of a burning coal; and in this case the emanation is also screened by a plate of mica. It was also found, that the magneto-electrical spark from a surface of mercury, excites the luminous condition of the sulphuret; and it has long been known that heat, applied to the bottom of the vessel containing the article, produces the same effect.

To determine whether the phosphorescence could be excited by electro-dynamic induction, a quantity of the sulphuret was placed between two plates of quartz, and a covered copper wire was wound around the whole, so that the lime occupied the axis of a spiral. But when a discharge of electricity was passed through the wire, the lime gave no indications of phosphorescence: the same negative result was also obtained, when the sparks were passed through the bottom of the leaden pan.

It has been supposed, that the phosphorescence of the lime is due to the disturbance of the electricity of the mass of the substance, and the continuance of the light to the subsequently slow restoration of the equilibrium. The result, however, of the following experiment would seem to be at variance with this explanation. The lime was thrown into a tumbler of water, and sunk to the bottom; but in this situation, when the spark was passed over the surface of the liquid, it became as luminous, and the effect appeared to remain as long, as when the exposure took place in the air.

Professor H. observed, that some of the experiments described by him can be repeated with common chalk, although it is not as sensitive as the sulphuret of lime. Some pieces of it, however, become luminous at a considerable distance, and it is not improbable that the chalk cliffs of England are sometimes rendered phosphorescent by flashes of lightning during a thunder storm.

But the substance which gives the most brilliant light, although the light does not continue so long and is not as easily excited as that from the lime, is the sulphate of potassa. When exposed to the discharge of a jar highly charged, at the distance of a few inches below the spark, it glows for a few seconds with a beautiful azure light: and as this salt is not readily acted on by liquids, it was used to determine the permeability of different substances, by placing a crystal of the salt in the liquid to be tested.

It has long been known, that the sulphate of potassa often emits flashes of light during the progress of its crystallization; and it is probable that other substances, which are known to emit light under the same circumstances, may also be rendered phosphorescent at a distance by the electrical emanation.

The following is a list of substances which have been examined by Professor Henry, with reference to their permeability by the phosphorogenic emanation.

Transparent Solids,
Permeable.

Ice,
Sulphate of lime,
Quartz,
Sulphate of baryta,
Sulphate of potassa,
Sulphate of soda,
Borax,
Citric acid,
Rochelle salt,
Common salt,
Alum,
Horn, (pellucid)
Wax, (do.)

Transparent Solids,
Imperfectly Permeable.

Tourmaline,
Mica,
Flint glass,
Crown glass,
Saltpetre,
Tartaric acid,
Hyposulphate of soda,
Copal,
Camphor,

Transparent Liquids,
Permeable.

Water,
Solution of alum,
Solution of ammonia,
Sulphate of magnesia,
Nitrate of ammonia,
and all weak solutions.

Transparent Liquids,
Imperfectly Permeable.

Muriatic acid,
Sulphuric acid,
Nitric acid,
Phosphoric acid,
Sulphate of zinc,
Sulphate of lead,
Acetate of zinc,
Arsenious acid,
Ammonia,
Spirits of turpentine,
Alcohol,
Ether,
Oil of aniseed,
Acetate of lead.

Dr. Hays made an oral communication "On the Family Proboscidea, their general character and relations, their mode of dentition, and geological distribution," illustrating his subject by numerous specimens, models and drawings.

This family, which embraces four recognised genera—Elephas, Mastodon, Tetracaulodon and Dinotherium—is, he said, a particularly interesting one, in several points of view. It comprises the largest of all the known terrestrial mammalia: the species were numerous: they inhabited the earth, over a large geographical range, at a former period, in immense numbers: and at the present time the whole race, with the exception of two species only, belonging to the same genus, is wholly extinct. Finally, we are enabled in this family to trace by remarkably close links the connection between the ancient and existing world.

Dr. H., after noticing the general characters of the Elephant and Mastodon, gave a brief sketch of the progress of discovery of the latter.

Single bones of this animal were occasionally found from an early period after the colonization of this country; but it was not until 1801 that any thing like an entire skeleton was procured. For this valuable contribution to science we are indebted to the zeal and indefatigable exertions of our fellow member, the late C. W. Peale, by whom two nearly complete skeletons were exhumed, near Newburgh, New York. A few years subsequently, one of our former presidents, Mr. Jefferson, engaged General William Clark, so honourably known by his journey to the Pacific Ocean across the Rocky Mountains, to explore Bigbone Lick, for the purpose of collecting animal remains, and furnished the pecuniary means for the undertaking. A very valuable collection of bones was the result of this expedition. From these Mr. Jefferson requested Dr. Wistar to select for our Society a specimen of every thing new and interesting, and to send the duplicates to the French Institute. By some mistake, several of the bones intended for our Society were sent to France; the greater number however reached us, and are now in our cabinet. The specimens sent to Paris, with the drawings and description by Mr. Rembrandt Peale of the skeletons discovered by his father, furnished the principal data by which Cuvier was enabled to develope the history of this extinct animal.

The only very important part of its skeleton not discovered was the cranium. Mr. Peale completed his skeletons by modelling this part after that of the elephant, the nearest allied animal. But in 1838, an entire head was found in Ohio. This specimen, which was figured and described in the eighth volume of our Transactions, was exhibited by Dr. Hays to the meeting.

In 1830 a most valuable contribution to our knowledge of this group of animals was made by our fellow member, the late Dr. J. D. Godman, who communicated to the Society a description of a new genus, which was published in the third volume of our Transactions. The principal characteristic of this genus was the possession of tusks in the lower jaw, whence it was named Tetracaulodon. Doubts were expressed at the time respecting this genus; but the discussion which took place on the subject, Dr. H. stated, was too recent to require that he should recal the particulars. But the investigation to which it gave rise was productive of one interesting result which should be mentioned; namely, the discovery of the number of molar teeth possessed by the Mastodon, which was supposed by Cuvier to be only twelve, or at most sixteen, but which was proved in a paper communicated to our Society in 1831, and published in the fourth volume of our Transactions, to be twenty-four.

Attention has lately been again directed to these animals, by a large collection of their bones, made by Mr. Koch in Missouri, which was exhibited a short time since in this city, and is now in London. These fossils seem to have deeply interested the English naturalists; three elaborate memoirs in regard to them having been read to the Geological Society. Prof. Grant and Mr. Naysmith, the authors of the two most recent of these papers, fully recognise the genus Tetracaulodon.

Dr. H. next alluded to the general characters and habits of the Dinotherium, the largest of the known terrestrial mammalia. A head of this animal lately discovered is more than three feet long, and as much in breadth. A model of this head was shown. The animal is calculated to have been eighteen feet long.

Some remarks were offered respecting the animal described by Prof. Kaup, under the name of Mastodon longirostris. This Dr. H. considered as the connecting link between the Tetracaulodons found in this country and the Dinotherium, and he suggested that it may prove to be a distinct genus. Attention was called to diagrams of the lower jaws of this group of animals: their relations and differences were pointed out, and some observations were made on the natural quinary group which they formed.

Dr. H. invited attention to the elongation of the lower jaw in the Mastodon, as compared with the Elephant,—its being armed with a short tusk projecting in a line with the base, in the Tetracaulodon,—the elongation of the chin and its downward curvature, with the increased length and curvature of the tusk, in the M. longirostris,—and finally, the still greater elongation and increased curvature of the chin, and the elongation and increased curvature of the tusk, in the Dinotherium.

The tusks of the upper jaw, large in the Elephant, are still larger in the Mastodon, whilst in the Dinotherium they do not exist; and Dr. H. suggested, that when a complete head of the M. longirostris is discovered, it will probably be found that the tusks in the upper jaw are of much inferior size to those of the Mastodon.

The mode of dentition of this family was next described, and the dental formula of the genera given as follows:

Elephant, Inc. $\frac{2}{0}$, can. $\frac{0}{0}$, mol. $\frac{8-8}{8-8}$, $= 34$.

Mastodon, Inc. $\frac{2}{0}$, can. $\frac{0}{0}$, mol. $\frac{6-6}{6-6}$, $= 26$.

Tetracaulodon, Inc. $\frac{2}{2}$, can. $\frac{0}{0}$, mol. $\frac{6-6}{6-6}$, $= 28$.

Dinotherium, Inc. $\frac{0}{2}$, can. $\frac{0}{0}$, mol. $\frac{5-5}{5-5}$, $= 22$.

The geological distribution of this family was next considered.

The Dinotherium and M. (T.) longirostris inhabited the earth at as early a period as the Miocene, and other members of the family successively existed up to the present time. Most of the species of Mastodon are found in the older Pliocene formations, whilst the Mastodon giganteum and the extinct Elephants existed during the latest portion of this period. The individual of this species, whose head was exhibited, must have become extinct subsequent to the deposite of the materials upon which grow the present forests of Ohio.

Of still more recent extinction must have been the Mammoth (Elephant), found in 1803 on the borders of the river Lena, encased in ice, the flesh of which was in such excellent preservation, that not only did the wolves and bears eagerly devour it, but the inhabitants actually cut up the flesh to feed their dogs.

Two species of this family, the Asiatic and African Elephant, are at present living inhabitants of the earth; but as their congeners have become extinct under the slow and gradual influence of causes still in operation, they are doubtless destined to the same fate—to have their bones at some future period inhumed with those of the human race and other existing animals, in formations now in progress.

In support of this position, Dr. H. adduced the fact of several animals having become extinct during the brief time embraced within the historical period. The Dodo, for example, numerous formerly in the Mauritius and Isle of Rodriguez, has for more than a century been entirely extinct. The garnet-winged dove, very common as late as Cooke's time at Tahiti, was said, on the authority of Mr. T. R. Peale, to be now also extinct. A very remarkable pigeon, not long since abundant at Upolu, one of the Samoan group, has become so rare, that two years since Mr. T. R. Peale could obtain only two specimens; and a year subsequently, though the greatest exertions were made, not a single one could be procured. The circumstance which had caused the extinction of this bird was related.

The Babinus auris vulpinus must also have become extinct within a comparatively recent period. This shell is found abundantly *under* the soil at St. Helena, but not yet fossilized. It is never found living.

Human bones have never been found fossilized, the creation of our species being too recent for such an event to be accomplished. In the few instances in which they have been found mingled with those of extinct species, the circumstance can be readily accounted for. Human bodies are, however, occasionally entombed by various occurrences; as by the lava thrown out by volcanic eruptions, which have buried whole cities; by landslips and drifting sands; in the chasms caused by earthquakes; and they are sometimes encased in the calcareous deposits from water. Examples of all these were adduced. The skeletons of those thus entombed will in the course of time become fossilized. The skeletons in the recent formation at Guadaloupe were noticed, and also the human bones found in Travertin, near Santas in Brazil; and some of these bones, with their calcareous incrustation, cemented to fragments of serpula, ostrea, &c., were exhibited.

Dr. Hays concluded with some remarks on the changes which have taken place in organized bodies, corresponding to the change in the condition of the surface of the earth,—on the proofs they afford not only of an Intelligence, adapting mechanism to an end, but of successive manifestations of the same contriving Intelligence, adjusting the mechanism to the altered conditions under which it was to exist,—and on the reverential and exalted ideas this ought to impress on us respecting the wisdom, power and goodness of the Creator, by whose fiat all things are called into existence and made to perish, and who alone endures for ever, and whose years have no end.

The communication was illustrated by entire heads of the Mastodon giganteum and Elephas Asiaticus, several jaws and casts of different species of Mastodon and Tetracaulodon, with series of teeth, casts, diagrams, &c.

In the absence of the author, Professor Frazer gave a succinct analysis of a written communication "On Analytical Trigonometry," by Professor Strong, of Rutgers' College, New Brunswick, N. J.

In this communication Professor Strong has reduced from simple principles, by the application of ordinary algebra, all the formulæ necessary for the computation of circular arcs and their co-ordinates.

Starting from the simple relations of similar right-angled triangles, he first obtains an expression for the tangent of double an arc in terms of the tangent of the arc itself, $\left(\tan.\ 2x = \frac{2\ \tan.\ x}{1 - \tan.^2 x}.\right)$ Then by changing the form of this equation, taking its hyperbolic logarithm, and developing this by a well known formula, he shows, that if the tangent of an arc be expressed in terms of the arc, it will be a function of that arc, in which the coefficient is constant, and from the limiting ratio of an arc and its sine that this coefficient is unity. Consequently, the expression becomes, x (the arc) $= \tan.\ x - \frac{\tan.^3 x}{3} + \frac{\tan.^5 x}{5} -$ &c.

Then again, by introducing into his expressions the sine and cosine of the arc (x), and making with the fundamental principle of the hyperbolic logarithm, that, if n be any number, &c., the base of the system of logarithms, then $n = {}^{c\ \log.}\ n$, he obtains, by a series of beautiful and ingenious transformations, $\cos.\ x = 1 - \frac{x^2}{2} + \frac{x^4}{2.3.4.} -$ &c., and $\sin.\ x = x - \frac{x^3}{2.3} + \frac{x^5}{2.3.4.5.} -$ &c., which enable us always to calculate the values of sine x and cos. x for any finite value of x.

Again, from the same principle, by adopting a different method of analytical reasoning, he obtains the still more familiar formulæ for the sines and cosines of a compound arc, in terms of the sines and cosines of its parts, which are fundamental equations of analytical trigonometry.

$$\text{Cos.}\ (x \pm y) = \cos.\ x \cos.\ y \mp \sin.\ x \sin.\ y.$$

$$\text{Sin.}\ (x \pm y) = \sin.\ x \cos.\ y \pm \cos.\ x \sin.\ y.$$

From these he deduces the correlative formula to the tangent of a compound arc, $\tan.\ (x \pm y) = \frac{\tan.\ x \pm \tan.\ y}{1 \mp \tan.\ x \tan.\ y}.$

From this expression he proceeds to obtain the value of the circumference of a circle, in terms of the diameter, proving the correctness of his analysis by obtaining the familiar ratio 3.141592 +.

Also, by substituting nx for x, and assuming $y = \cos. x + \sin. x \sqrt{-1}$, he obtains values of y, by which we are enabled with facility to divide the circumference of a circle into any number of equal parts, and thus to inscribe any regular figure within it.

Professor Bache presented a written communication, by Professor Elias Loomis, of Western Reserve College, Hudson, Ohio, "On two Storms which occurred in February, 1842."

In this paper, Professor Loomis makes an analysis of the phenomena attending two storms, which occurred, respectively, about the fourth and sixteenth of February, 1842, and draws his theoretical conclusions in the way pursued by him in a paper on the storm of December 20th, 1836: which was published in the Transactions.

The materials for his inductions, in relation to these first storms, were as follows:—sixty-eight registers containing barometric observations at points between longitude 91° 25′ and 52° 38′ W., and latitude 47° 34′ and 25° 16′ N.; fifty-nine registers of the thermometer and weather from military posts; and twenty-two registers of a similar sort from private observers, besides others of the weather merely. To these numerous observations, Prof. Loomis expects yet to be able to add others.

The principal phenomena of the storms are represented upon charts, so as to show distinctly the limits of each. Thus the regions of the United States, where at an assumed epoch the sky was clear or clouded, and where rain or snow was falling, are indicated by different colours. The direction and force of the wind are shown by arrows, and lines of equal pressure and of equal temperature of the air are drawn. There are five charts representing the principal epochs of the storm of Feb. 16th, and seven showing those of Feb. 4th. By the aid of these, Prof. Loomis makes a review of the phases of the storms, weaving into the narrative additional observations of the fall of rain and snow, and the direction and height of the clouds.

He next proceeds to investigate the proximate causes of the phenomena under several distinct heads. I. The oscillation of the thermometer. Both these storms, as well as that of Dec. 1836, were accompanied by a considerable rise of the thermometer. During the storm of December and that of February 16th, the thermometer rose 20° above its mean height for the epochs, and in that of February 4th, 30°. Prof. Loomis, after examining the different causes which may have produced this rise, fixes upon the transfer of air from a lower to a higher latitude as the chief; and having already shown that there was such a transfer, brings facts to prove that there is sufficient to explain the observed results.

The fall of the thermometer, which succeeded the storm, is in like manner traced to the transfer of air, from a higher to a lower latitude.

II. Causes of the rain. The cause attributed by Prof. Loomis, in the storm of Feb. 16th, is the configuration of the surface of the United States between the Atlantic coast and the mountains, by which moist air from the ocean was raised to a higher elevation, thereby cooling it, and by which it was carried to mingle with a colder upper current from the west or south-west. This rise, however, may in his view be produced by various circumstances.

III. The motion of the wind. Professor Loomis gives his views of the cause of the winds observed, as follows:—"That an easterly wind should spring up on the morning of February 15th, in the region of Ohio, was the necessary result of the greater weight and density of the air to the eastward. But a westerly wind at the same time prevailed a little beyond the Mississippi river. These two winds were partially opposed, and from their opposition, the air between them was elevated somewhat above the surface of the earth. Being cooled by diminished pressure, its vapour is condensed; a portion of it falls as snow, and the remainder forms clouds, which expand and cover the surrounding country. The condensation of the first vapour developes heat, which diminishes the specific gravity of the surrounding air, thereby causing a more decided tendency toward the storm, which increases the precipitation and the development of heat, so that the storm increases in violence as it continues. In the region of greatest condensation, the rise of the temperature was probably greater than at the surface of the earth. As the result of this rarefaction, the air swells up above its usual height, and flows off in every direction, carrying with it the cloud already formed, and causing the barometer to fall steadily as the storm continues to rage."

Professor Loomis investigates the amount of effect attributable to this cause, and makes the application to this particular storm,—shows that the violence of the storm must increase,—that in meeting the general current from the westward, prevailing in the higher regions of the atmosphere, the centre is carried eastward,—and that there must be a general motion of the lower or surface wind inward, with a tendency to circulate "against the sun;" all these deductions agreeing with observations. He next examines the questions—what caused the first formation of cloud, and why should a storm, when once organized, cease; concluding, in regard to the first point, that each storm begets its successor, the clouds observed on the 15th of February resulting from the atmospheric disturbance by a preceding storm; and in regard to the second, finds the necessary check in the influence of the cold north-west wind, which, in the storm of February 16th, was observed to flow in more rapidly than the centre of the storm advanced eastward.

A similar investigation is made of the circumstances of the storm of February 4th, which was one of several centres, and was rendered remarkable by the occurrence of a violent tornado in the north-eastern part of Ohio. In this tornado, an inward motion of the air was observed with a circulation against the sun, and is described by Prof. Loomis in the 43d vol. of Silliman's Journal.

IV. Oscillation of the barometer. Professor Loomis argues, that though local changes in the density of the air are the chief causes of the fluctuation of the barometer, nevertheless these oscillations are propagated according to the law of waves, and are felt much beyond the limits of the original disturbing cause: thus the barometric depression occurring with the storm of February 4th, extended considerably south of the region of rain, or even of cloud.

Professor Loomis next proceeds to certain generalizations, treated under the heads of direction of the wind and progress of the storm. Considering the most simple cases (normal cases) of centripetal and rotary storms, or in which the wind flows inwards in all directions, or gyrates about a centre, Professor Loomis concludes that neither of the storms now described belongs to either class; that indeed it is doubtful if the motion of the wind over a large portion of the earth's surface ever conforms strictly to either supposition, but that it frequently partakes of both the alleged motions. Several cases of storms are referred to in support of this position. Defining the centre of a storm to be the point where the greatest barometric depression is found, Professor Loomis traces both the storms under discussion, in a general northward and eastwardly direction, but varying both in rate and direction within limits which he assigns.

The conclusions to which Professor Loomis arrives are as follows:—

"The following, then, is my view of the origin of such storms as I have been investigating. This generalization will probably include the greater part of winter storms, but will require some modifications when applied to summer showers. Imagine a time perfectly clear, when the wind is from the west, with the barometer and thermometer at their mean height. This may be regarded as the normal state of the atmosphere, and the whole body of air, from its upper limit to the surface of the earth, is moving on harmoniously in one direction. How is rain produced in such an atmosphere? The first requisite seems to be a change of direction of the lower stratum of air. This appears, in winter, to be frequently the effect of a preceding storm. The prevalent westerly current, being temporarily checked in its progress by a violent storm, soon acquires force sufficient to break down all opposition. It supplants the rarefied air of the storm, and not only restores the barometer to its mean height, but the momentum of the excited mass carries it considerably above the mean. This excess of pressure causes a reverse current a little to the westward of a violent storm; and hence we sometimes have a long series of violent storms succeeding each other at nearly equal intervals; and hence, also, a violent storm, succeeded by an unusually high barometer, affords ground for expecting a second storm within one or two days. But this explanation will not apply to all cases; for then, if the barometer should ever settle down to its mean height all over the globe, we never could have another storm. The case here supposed is not likely ever to happen; but even if it should, we cannot admit the consequence attributed to it. Admit such a case to occur, and the sun's heat would be competent to generate a new storm.

"Different portions of the earth's surface absorb the sun's rays in unequal degrees, and afford unequal quantities of moisture for evaporation. The result is, we find bodies of air in close proximity of unequal density, arising from unequal temperature or humidity. Either case would be sufficient to cause a deflection of the lower stratum of air from its normal direction. Suppose then we have the mass of the atmosphere pursuing its wonted course from west to east, while a stratum of a mile or so in height next the earth's surface blows in some different direction; if this direction be from south to north, then the current must be cooled in its progress by change of latitude. This effect may be aided by the inequalities of the earth's surface, and by friction upon the upper stratum of colder air. At the surface of the earth, when the temperature is probably five or ten degrees above the dew-point, no remarkable effect may follow. But at a certain elevation, the air is always saturated with vapour. A very slight reduction of temperature causes cloud, and its density and extent will be proportioned to the energy of the causes in operation. If the wind should blow from the north it might happen that no cloud would be formed; but if the direction should be easterly, being partly opposed to the normal current, some portion of this mass would almost necessarily be elevated from the earth's surface, and being cooled, its vapour would be condensed. The first stage of this process then is an abnormal current at the earth's surface, the second is the production of cloud. At this stage, the sky is covered with a veil which checks radiation; the thermometer rises above the mean from this cause, and also from the heat liberated in the condensation. This only adds to the energy of the first abnormal current. More cloud is thus formed, and presently the particles of water having acquired sufficient size, fall rapidly to the earth. The wind being southerly, the thermometer rises. A portion of the atmosphere being thus unusually heated, and loaded with vapour, while the upper limit of the atmosphere remains nearly invariable, the barometer necessarily falls. Thus these causes might continue to operate a long time, acquiring energy by their own action. A limit, however, is soon attained. The rarefaction thus produced, creates a tendency in the surrounding colder and heavier air to rush in and occupy its place. Moreover, if the wind be at all easterly, as is usually the case, it partially obstructs the progress of the normal current. This temporary retardation but gives it accumulated energy, and it is soon reinstated with unwonted violence. When the rarefaction is considerable, this rush of air upon the last half of a storm is not generally in the precise direction of the upper current, but more northerly, this air being the denser, and our southerly wind is supplanted by a violent north-wester. We have thus a great rarefaction and elevation of temperature under a south or south-east wind with rain, extending over a large territory. This may be called the third phase of the storm, although it differs from the second only in intensity. There is now a general rush of heavier air to fill this void. This rush is chiefly from the north; but an independent cause, that which imparts direction to the upper current, would give us a west wind. Under these two forces the resulting current is chiefly north-west, but every where upon the borders the tendency will be inward. The air thus flowing inward towards a central area, forces upwards the warmer air which rises in the middle, and being cooled by elevation, discharges a greater quantity of rain. The currents moving centrally from every point of the compass interfere with each other and pursue their routes spirally inward. We have thus a species of rotation, which in the centre of the storm may have a destructive violence, as at Mayfield, February 4, 1842. This is the fourth phase of the storm, and is the case of a violent storm fully organized. This west or north-west wind carries the storm off from a fixed locality, and the storm is transferred necessarily to points further and further east. But this action cannot continue indefinitely. There is a cause in operation which will soon terminate its violence. This westerly wind travels more rapidly than the easterly. The rarefaction at the centre of the storm is a cause which acts equally upon both winds. But the one is opposed to the upper current, and the other nearly coincides with it. Hence the one is accelerated and the other retarded. The result is that at successive points farther and farther east, the same storm, after the north-west wind has begun to blow with great violence, has a less duration, the thermometer rises to a less height, the barometer has a smaller oscillation; and thus at a point far eastward, the oscillation becomes nearly extinct, and the only peculiarity observed in the wind is a stronger westerly current succeeding a calm. This is the fifth and final phase of the storm."

Prof. Loomis adds in conclusion:

"It appears to me that if the course of investigation with respect to the two storms of February 1842 were systematically pursued, we should soon have some settled principles in meteorology. If we could be furnished with two meteorological charts of the United States daily for one year, charts showing the state of the barometer, thermometer, wind, sky, &c., for every part of the country, it would settle forever the laws of storm. No false theory could stand against such an array of testimony. Such a set of maps would be worth more than all which has been hitherto done in meteorology. Moreover, the subject would be well nigh exhausted. But one year's observation would be needed. The storms of one year are probably but a repetition of those of the preceding. Instead then of the Guerrilla warfare which has been maintained for centuries with indifferent success, although at the expense of great self-devotion on the part of individual chiefs, is it not time to embark in a general meteorological crusade? A well arranged system of observations spread over the country, would accomplish more in one year, than observations at a few insulated posts, however accurate and complete, continued to the end of time. The United States are favourably situated for such an enterprise. Observations spread over a smaller territory would be inadequate, as they would not show the extent of any large storm. If we take a survey of the entire globe, we shall search in vain for more than one equal area which could be occupied by the same number of trusty observers. In Europe there is opportunity for a like organization, but with this incumbrance, that it must needs embrace several nations of different languages and governments. The United States then afford decidedly the most hopeful field for such an enterprise. Shall we hesitate to embark in it? or shall we grope timidly along as in former days? There are but few questions of science which can be presented in this country to the same advantage as in Europe. Here is one where the advantage is in our favour. Would it not be wise to devote our main strength to the reduction of this fortress? We need observers spread over the entire country at distances from each other not more than fifty miles. This would require five or six hundred observers for the United States. About half this number of observations is now registered in one shape or another, and this number by suitable efforts might probably be doubled. Supervision is needed to introduce uniformity throughout, and to render some of the registers more complete. Is not such an enterprise worthy of the American Philosophical Society? The general government has for more than twenty years done something, and has lately manifested a disposition to do more for this object. If private zeal could be more generally enlisted, the war might soon be ended, and men would cease to ridicule the idea of our being able to predict an approaching storm."

This communication was elucidated by numerous charts, projected on a large scale, from drawings prepared by the author.

The reading of it having been completed, Dr. Hare made some observations on the several theories of storms which have been presented by meteorologists. He adverted to Mr. Espy's theory, which he considered inadequate to explain the phenomena of the tornado, referring them himself to the action of electricity.